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16. Abstract <i>This paper reports the results of the continuing analysis of ERTS-1 imagery covering Iowa during 1972 and periods during 1973. Emphasis is placed on the identification and classification of major crop types at two test sites in Iowa. Standard photo-interpretive methods were used in this analysis including the direct enlargement of black and white single-band products and additive color multi-band procedures using a miniadcol system. The use of sequential coverage during the crop growing season is emphasized as a means to improve the effectiveness of ERTS-1 photo interpretations of crop land acreage estimates in Iowa. Illustrative black and white and color prints of both ERTS-1 and underflight imagery are included. In addition, forest land inventories at one test site are reported. A new method for the inventory of forest lands using ERTS-1 imagery is reported and compared with estimates obtained using earlier underflight imagery.</i>				
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PREFACE

a) Objective

The objectives of this investigation are as follows:

1. To evaluate how remote sensing data can be utilized in Iowa to better or more economically define the soil and plant parameters that are important in production and marketing of agricultural crops.
2. To evaluate the ERTS-1 satellite for conducting forest land, crop land and soil classification surveys by noting the constraints of the system, by identifying problem areas and by suggesting solutions to these problems where possible.
3. To determine how these data can be utilized in decision-making processes involving optimum utilization of our natural resources.

b) Scope of work

The research effort at Iowa State includes researchers in plant pathology, agricultural climatology, soil classification and morphology, forestry and photography and their associated problems related to remote sensing using both satellite and underflight imagery of various formats. Standard photo-interpretive methods have been used to date in the analysis of this imagery as digitized data have not been requested.

c) Conclusions

ERTS-1 imagery covering test sites in Iowa during 1972 provided only single time coverage with good quality imagery. This imagery was analyzed with respect to crop inventory, using various techniques. These results are reported. The classification and inventory of major field types were not fully achieved because single time coverage does not generally permit complete discrimination of all major field types. During the 1973 crop growing season to date, one test site has been viewed by ERTS-1 with relatively cloud-free conditions five times. Preliminary analysis of this sequential coverage appears to enhance the probability of discrimination between major crop types. The visual response of major crop types has been observed at each time and should provide good discrimination. In addition, color additive work on this data is in progress and should provide a good multi-spectral and sequential coverage analysis technique at two test sites.

Preliminary work has been completed with respect to forestland inventory. Results have been favorable; however, this work will continue in order to select the seasonal ERTS-1 imagery which provides the best separation of forestland from other types of land use.

d) Summary of recommendations

The analysis of the bulk 70 mm black and white ERTS-1 imagery received continues using standard photo-interpretive methods. No digitized data have been requested at this date. Based on the experience gained from the single date August 1972 coverage of ERTS-1, small field sizes and the diversity of land use in Iowa will remain as problems to be resolved for crop inventory using visual type analysis. Some areas in Iowa appear more detailed than other areas. Preliminary results indicate that multi-band and sequential coverage of the same site will minimize these problems and should maximize the amount of information extractable from ERTS-1 coverage. Where ERTS-1 has successfully viewed the same surface at different dates, it appears that fairly unique spectral responses exist for major crop types in Iowa, but diffuse field boundaries still exist. This hinders area estimates. Imagery other than bulk 70 mm black and white has been requested hoping to lessen that problem. It is, however, difficult to obtain acreage estimates over large areas using visual photo-interpretive techniques rather than digitized data.

BODY OF REPORT

Introduction

Various agencies in Iowa are greatly concerned about the natural resources of Iowa. Crop acreage estimates, forest inventories and the classification of soils are examples all relating to land use. In order to obtain these estimates, sampling type surveys have been previously employed. Advances in the field of remote sensing and photo-interpretation have provided vehicles by which large areas can be examined at one time. This report assesses the capabilities of ERTS-1 and low-level underflight imagery of various formats to provide insight as to their utility with respect to crop land estimates, to forest land inventories and to soil classification in Iowa.

Methods of Analysis

Three areas with differing soils and cropping patterns in Iowa were selected for experimentation. In addition, other areas have been examined as new ERTS-1 imagery was received. At Iowa State the analysis of the acquired imagery has followed standard photo-interpretative techniques. Digitized data have not been requested to date. The interpretative techniques are as follows: 1) direct enlargement of the 70 mm positive transparencies, 2) additive color procedures using the I²S Miniadcol system located at and with the permission of the Iowa State Geologic Survey - Remote Sensing Center at Iowa City, Iowa and 3) direct examination of the 70 mm positive transparencies using a low power microscope with an x-y vernier stage.

Ground truth data have been acquired at these test sites for later correlation with the conditions indicated on the ERTS-1 imagery. A part of this ground truth has been obtained through underflights provided by NASA in the early spring and late summer time periods. This particular ground truth has been an indispensable part of this investigation and it has provided very precise record of ground conditions not otherwise available to this research group. The imagery format has been reported in previous Type I reports.

Results and Discussion

The diversity of the studies of individual researchers involved with this investigation is such that each investigator's results and discussion section will be discussed separately on the following pages of this report.

Results and Discussion: Cropland Inventory by Richard E. Carlson, Assistant Professor of Agricultural Climatology, Iowa State University

a) Ames, Iowa flightline (1972)

Acreage estimates of corn and soybean present in twelve sections in the Ames flightline were determined from August underflight imagery. They were 2651 and 2046, respectively for corn and soybeans. These estimates were assumed correct and similar estimates of the corn and soybean acreage were obtained utilizing the August ERTS-1 imagery. Various methods were employed as facilities for quantifying the ERTS-1 imagery were not available. Point sampling for crop identification does not attain the fullest potential of ERTS-1 or other remotely sensed data. Therefore, area estimates of particular crop types were attempted as they provide more useful data to users. The methods used were basically a project-trace-and-weigh procedure. Signatures for various crop types were established from known ground truth. These signatures for corn, soybeans and other were obtained by field by field comparisons of the August underflight imagery with August ERTS-1 imagery. During the August time period MSS5 and MSS7 appeared most useful providing the following multiband discrimination given in Figure 1.

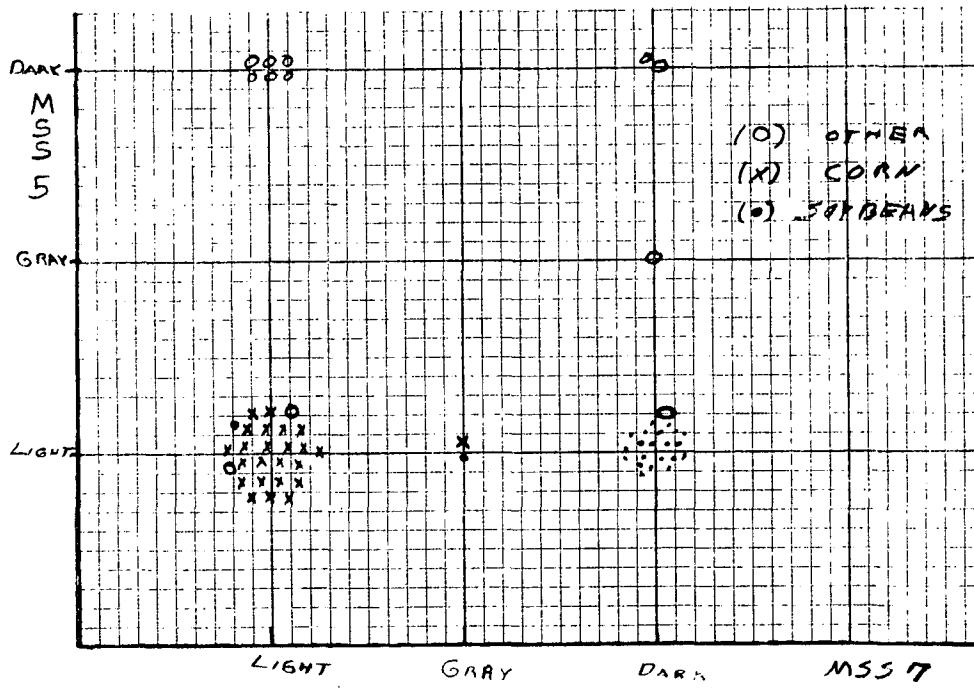


Figure 1. Cross tabulation plot of known field visual responses as viewed on black and white enlargements of MSS5 and MSS7 ERTS-1 imagery covering the Ames flightline on August 13, 1972.

In order to further verify the results given in Figure 1, 118 randomly selected points were placed in the 12 section flightline. Another photo-interpreter classified these points using the spectral response based on Figure 1 and black and white enlargements of MSS5 and MSS7. He obtained the results noted in Table 1.

Table 1. Error analysis of field type classification for 118 randomly placed points in the twelve section Ames flightline using August - 1972 ERTS-1 MSS5 and MSS7 black and white enlargements.

P.I.'s results from ERTS-1		Ground Truth			Total seen by P.I.	Commission Error	Percent
		Soybeans	Corn	Other			
	Soybeans	48	6	0	54	6	11.1
	Corn	12	39	1	52	13	25.0
	Other	0	2	10	12	2	16.7
	Total Plots	60	47	11			
	Omissions	12	8	1			
	Percent Correct	80.0	83.1	90.8			

Many of the fields misclassified were either small or abnormal fields as viewed on the low level color infrared imagery.

After point sampling established a spectral response discrimination for selected crops, black and white single band prints (MSS5 and MSS7), miniadcol produced color slides or photo-micrographs of 70 mm positive transparencies were projected onto a flat surface and the field types were traced, cut and weighed. The paper weight was converted to acreages using an adjacent calibration strip. A detailed description of each method follows.

- i) Miniadcol produced color slides: Color slides were taken of the miniadcol screen on which the ERTS-1 imagery was projected. The color filter used and wavelength selections were such that maximum contrast could be detected by the eye. The slides were then projected on the wall to attain appropriate enlargements. Ground truth areas were located and an identification scheme was established. By knowing which color filter and which ERTS-1 wavelength was used, it was possible to determine the response expected of various crop types. After a given color was established as corresponding to a particular crop type, acreages were obtained by outlining the designated color areas. These areas were then cut, weighed and converted to acreages through an adjacent calibration strip.
- ii) Opaque projected black and white prints: This method utilized the less sophisticated equipment; however, as will be shown later in the report, this method yielded quite good results. This method involved the projection of an individual black and white print (MSS5 and MSS7) onto a

flat surface. Areas corresponding to a particular field type were outlined, cut, weighed and converted to acreages. The signature for specific field types was established from the results of Figure 1. It was necessary to superimpose two wavelengths sequentially on the same tracing as signature analysis had indicated that single-band discrimination was not possible by visual analysis of enlarged black and white prints for most fields. It had been determined that a few fields yielded a dark response on both enlarged prints of MSS7 and MSS5, but that none of these fields were soybeans. Therefore, dark fields on MSS7 were outlined and MSS5 was projected onto this trace. Any dark areas on MSS5 corresponding to dark areas on MSS7 as indicated by the original outline were double outlined and were not cut out. The resulting areas outlined were then considered to be soybean fields in this example.

- iii) Photomicrograph method: This method is quite similar to the opaque projector method except for the form in which the imagery was projected onto the screen. Photomicrographs were taken of the 70 mm positive ERTS-1 transparencies (both MSS5 and MSS7) using a low power microscope. This method was attempted because there were heating problems using the opaque projector over long periods of time. In addition, we were attempting to increase the resolution of the projected imagery. When used for acreage analysis, the projected imagery on the screen was treated as with the opaque projector method, including superimposing the two ERTS-1 wavelengths. It should be noted that, as with the opaque projector method, difficulty is encountered when attempting to register one wavelength projection on the trace of another. In both methods the degree of difficulty depended upon the quality of the ERTS-1 imagery and the distinctness of field spectral response differences on the imagery.
- iv) Photocut method: The photocut method is similar to the previous methods discussed in that only single wavelengths were used as data at one time. No projectors or tracing were necessary. Black and white prints were enlarged to a scale which was workable and at the same time did not allow complete loss in image resolution. Area estimates were obtained by cutting fields from the print corresponding to the previously established spectral signatures. Combinations of two wavelengths were used for the determination of fields with multiband spectral signature discriminations. This was accomplished by overlying the two prints onto an intense light table. Very good registration is possible using this technique and this method has the advantage of being able to indicate exactly what areas have been included in the estimate. Also, once one crop has been cut, another signature can be designated by tracing the cut out areas of one imagery onto another image.

Another method used in the Ames flightline was as follows. The imagery was projected onto graph paper (10 lines/2.54 cm) and dots were placed at the intersection of lines on the graph paper which indicated a particular crop signature. The summation of dots placed was then converted to acreage estimates. The estimates obtained using four of these methods are listed in Table 2.

Table 2. Estimation of soybean acreages in twelve sections in the Ames flightline by 3 project-trace-and-weigh methods and 1 dot placement method.

Method	ERTS-1 estimate	Actual	Difference	Actual/ERTS-1 estimate
Miniadcol	2065	2046	19	.991
Photomicrograph	1813	2046	233	1.128
Photo-cut	1903 (2333) ¹	2046 (2651)	143 (318)	1.075 (1.136)
Dot placement	1804	2046	242	1.134

¹ corn acreage estimates in parenthesis

Even though the results in Table 2 are probably within the standard error of methods presently used to estimate crop land acreages, the field boundaries for the projected miniadcol slides were quite diffuse for many fields so an analysis of commission and omission errors was completed for three sections in the Ames flightline. These results are given in Table 3.

Table 3. Error analysis of crop type acreage estimates of projected miniadcol produced color slides for three sections in the Ames flightline (August - 72).

	ERTS-1 estimates			total	omission	%
	corn	soybeans	other			
corn	633	74	60	767	134	17.5
soybeans	62	365	51	478	113	23.6
other	180	127	358	665	307	46.2
total	875	566	469			
commission	242	201	111			
%	72.3	64.5	76.3			

This table indicates that errors can occur by misplacing field boundaries and, probably more important, missing small fields and larger fields which are predominantly long and narrow. This was verified by examining the low altitude color infrared imagery for this area. The field size distribution for soybean field sizes in the Ames area is given in Figure 2 and indicates 25% of the number of fields were less than 25 acres. Or visa-versa, 75% of the land area contained fields larger than 25 acres.

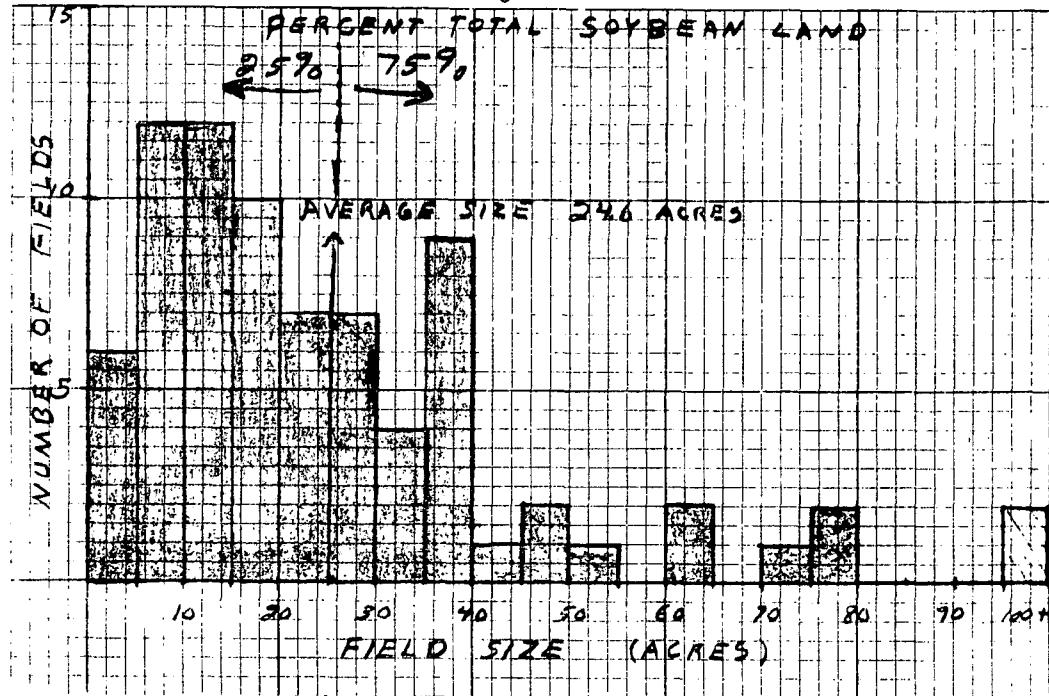


Figure 2. Distribution of soybean field sizes for the twelve sections in the Ames flightline.
(August 1972)

b) Doon flightline (1972)

Similar ERTS-1 acreage estimates were made in the Doon flightline; however, this proved to be a very difficult task in this part of Iowa using August imagery. The flightline covers an area including a small river drainage system. This influenced the response on MSS6 or MSS7 (used to separate corn from soybeans) such that field patterns were completely diffused. MSS5 was quite sharp and detailed in this area, but corn and bean fields are not separable using this wavelength alone at this time. Another feature of this area which makes soybean classification difficult is the fact that very few soybeans were present. The ground truth acreage for corn and soybeans in the 12 section flightline was 3517 and 702, respectively, for corn and soybeans.

Before any area estimates of field types were attempted in the Doon flightline, point-sample identification estimates were made using miniadcol produced color slides. The miniadcol slides were projected to an enlargement the same size as projected underflight imagery (black and white 5-inch film exposed with a #89 B filter). Points were planted according to underflight fields by one individual, then another individual classified each point on the miniadcol slide based on previously established color signatures. These results are given in Table 4.

Table 4. Error analysis of field type classification for 47 placed points in six sections of the Doon flightline using August 1972 ERTS-1 imagery of the miniadcol produced slide format.

P.I.'s results from ERTS-1	Ground Truth			Total seen by P.I.	Commission Error	Percent
	Corn	Soybeans	Other			
Corn	16	0	1	17	1	5.9
Soybeans	2	10	4	16	6	37.5
Other	5	0	9	14	5	35.7
Total plots	23	10	14			
Omissions	7	0	5			
Percent Correct	69.6	100	64.3			

Of the twelve fields misclassified in this analysis, seven fields exhibited abnormal responses on the low level color infrared underflight imagery.

After this point analysis, acreage estimates were attempted for five other sections in the Doon flightline using the ERTS-1 miniadcol produced color slides. Error analysis for these sections is presented in Table 5 using the project-trace-and-weigh procedure from miniadcol produced color slides.

Table 5. Error analysis for five sections in the Doon flightline using miniadcol produced slides (August 1972).

Ground Truth	ERTS-1 estimates			total	omission	%
	corn	soybeans	other			
corn	566	23	496	1085	519	47.8
soybeans	28	133	181	342	209	61.1
other	148	60	1750	1958	208	10.6
total	742	216	2427			
commission	176	83	677			
%	76.3	61.6	72.1			

This table indicates that considerable acreages of corn and soybeans were misclassified as other using the miniadcol produced slides. Overlaying ground truth on the ERTS-1 classification showed that major acreage errors can be directly attributed to the failure of the photo-interpretor to outline large enough areas for each field. This was a very difficult area to classify because the field boundaries were very diffuse and the individual field colors were not sharp and distinct. Very seldom were fields missed altogether as indicated in Table 4.

East of the Doon flightline, the image quality of MSS5 and MSS7 improved very markedly. This change is related to topography differences between these areas and the result that more uniform and larger fields are present east of the Doon flightline. This is illustrated in Figs. 3 and 4. (Note: the prints in this report are for illustrative purposes, larger prints were used for acreage estimates). For this reason, acreage estimates of corn and soybeans were attempted using the procedures described in part (a) of this section. These results follow.



Figure 3. A black and white print made from MSS5 of the August 1973 ERTS-1 imagery covering northwestern Iowa. The Doon flightline and the O'Brien County border are highlighted.

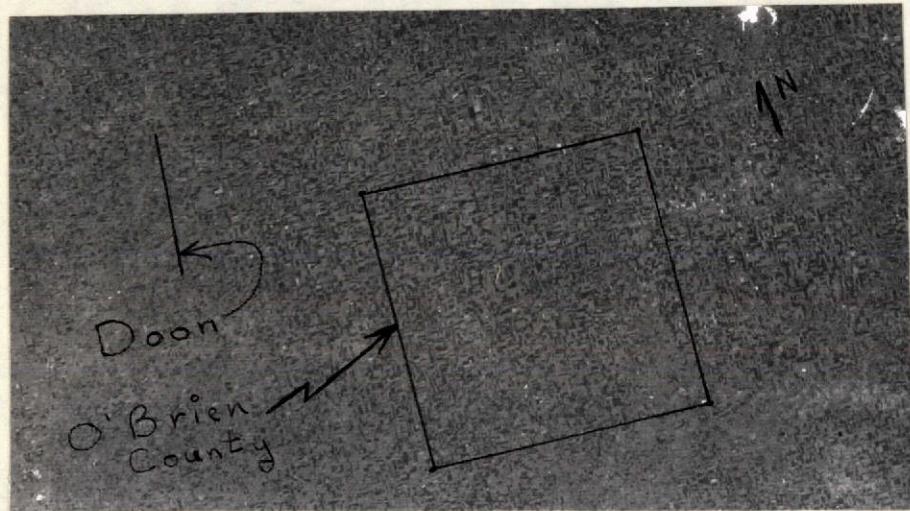


Figure 4. A black and white print made from MSS6 of the August 1972 ERTS-1 imagery covering northwestern Iowa. The Doon flightline and the O'Brien County border are highlighted.

c) O'Brien County (1972)

Actual ground truth was not available for this county. Estimated ground truth was requested and provided by the Iowa Crop Reporting Service for townships in O'Brien County, Iowa where 1972 corn and soybean acreage estimates existed. The results of the ERTS-1 acreage estimates are summarized in Table 6.

Table 6. Acreage estimates of soybeans for eight townships in O'Brien County, Iowa using four different methods.

Township	% of total land by townships					Differences			
	CRS	Mini	Opaque	Micro	Photocut	CRS-Mini	CRS-Opaque	CRS-Micro	CRS-Photocut
Franklin	19.9	20.8	21.4	23.4	27.6	-00.8	-01.4	-03.4	-07.6
Lincoln	26.0	25.3	29.2	26.0 ¹	27.4 ¹	00.7	-03.2	00.0	-01.4
Summit	32.9	20.1	31.2	--	--	12.8	01.7	--	--
Center	30.4	19.1	24.5	32.6 ²	30.0	11.3	05.9	02.2	00.4
Omega	23.5	16.4	21.8	--	--	07.1	01.7	--	--
Grant	23.9	14.9	23.2	24.8	--	09.0	00.7	00.9	--
Liberty	23.1	16.0	23.3	28.0	--	07.1	00.2	04.9	--
Waterman	10.4	15.2	10.7	--	--	04.8	00.3	--	--
						\bar{x}_{dif}	06.7	01.9	02.3
									03.1

¹ average of 2 acreage estimates

² average of 3 acreage estimates

It must be emphasized that the ground truth obtained from the Crop Reporting Service is an estimate based on sampling and not an estimate based on photo-interpretation of the area in question. For this reason, the Crop Reporting Service estimate may differ slightly from the true acreage present. The author feels that the comparisons in Table 6 are valid under these circumstances.

As in Table 5, Table 6 shows that the miniadcol produced color slides tend to underestimate soybean acreages, at least using this imagery. Again, this error probably arises from the fact that individual field sizes are underestimated. The most consistent and accurate method used in this analysis was the projection of enlarged prints using an opaque projector. The projected image was traced using previously established soybean signatures and, subsequently, weighed and converted to acres. With the exception of the photomicrograph projection technique for the first soybean acreage estimate in Center township, the remaining estimates are probably within the standard errors associated with these techniques.

These errors are related to the photo-interpreters ability to discern shades of black and white on the projected image, his ability to consistently place field boundaries in the same place due to the diffuseness of the ERTS-1 enlargement, the possibility that the calibration strip may be in error, and the errors associated with the cut-outs, cutting and weighing. In addition, these methods assume that all soybean fields in areas of interest yield distinct spectral responses. This is, in fact, not true as evidenced by the fact that earlier point sampling in the Doon area showed that some misclassified soybean fields were abnormal looking

fields on the low level color infrared imagery. It should be noted that in Table 6 where footnotes indicate that multiple acreage estimates were made for a given township using a specific method, these estimates were not completely consistent. An insufficient number of samples were obtained to develop reliable statistics; however, the variability was due mainly to the photo-interpreters ability to discern shades of black to white and accurately place field boundaries in the same position each time.

d) 1973 crop growing season - Doon flightline

Coverage of the Doon flightline has been very successful to date for both satellite and underflight coverage. Clear skies have prevailed 5 times between May 1973 to the present. In addition the flightline was covered by NASA provided underflights on May 15, 1973. Ground truth identifying fields in twelve sections of the flightline have been compiled. The visual response of these fields as observed on black and white enlargements have been recorded for each ERTS-1 pass. These results are listed in Figure 5.

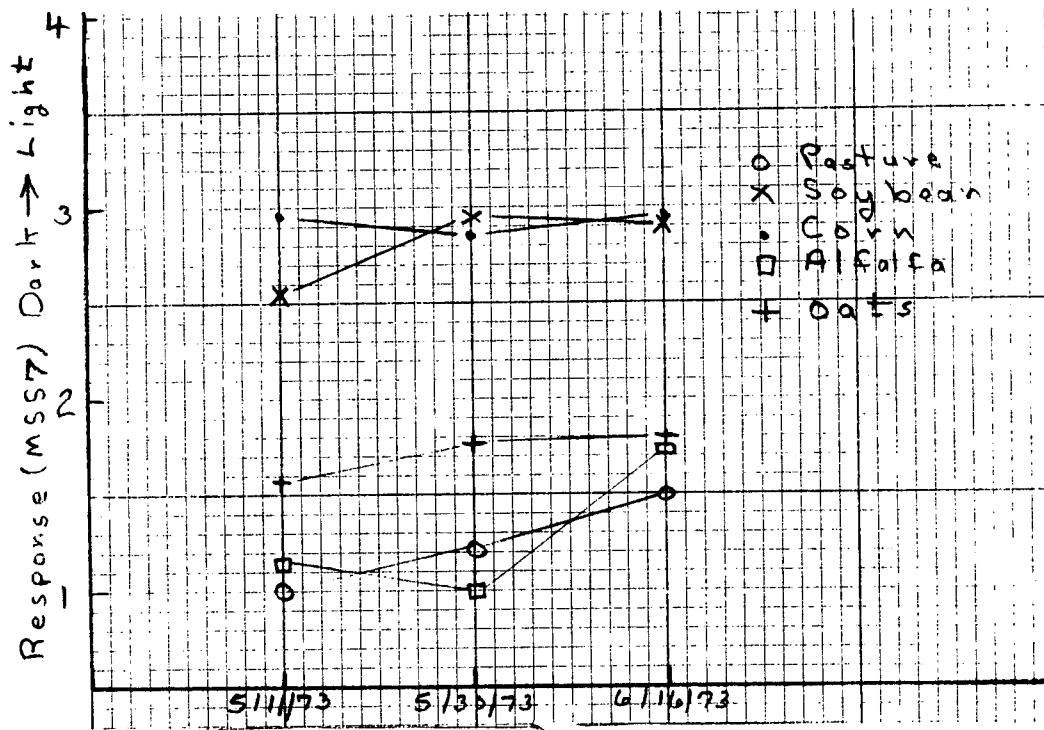


Figure 5. Visual spectral response during the 1973 crop growing season for different crop types as viewed on black and white enlargements of MSS7 in the Doon 1973 flightline.

Very small response differences were noted for corn, soybean and oat fields from early May through mid-June. Perceivable differences were recorded for alfalfa and pastures during that period. We are attempting to record these differences throughout the complete growing season in order to determine the times when maximum crop separation is possible. For example, using last years August ERTS-1 imagery, it was difficult to separate alfalfa and soybean fields because they have similar spectral responses at that time, providing the alfalfa was uncut. When imagery covers this area at different time periods, the problem is minimized. Photointerpretation of the spring imagery easily separates the alfalfa fields from the soybean fields as the two field types at that time are, respectively, a vegetated surface and bare soil. These separate easily on miniadcol produced ERTS-1 color slides. Similar problems existed in the classification of the corn fields. Here again, the main difficulty was in the separation of corn fields from other vegetated land, pasture land, oats stubble regrowth, etc. These field types would, as in the alfalfa-soybean problem, be classified sooner in the growing season than corn. Another point concerning this classification scheme is that after springtime imagery is analyzed, the remaining land area appearing as soil will most likely be either corn or soybeans in Iowa. Thus, by sequential analysis throughout the entire growing season, much more attention can be directed to abnormal soybean and corn fields conditions due to crop diseases and other stresses. This assumes that corn and soybean fields have separable spectral responses in late July or early August as was shown during the 1972 growing season. This is probably a good and reasonable assumption. If ERTS-1 coverage of this area continues successfully, then we hope to use both multi-spectral techniques and sequential coverage of the same area to classify crop lands.

Another point concerning single-band products is that in early spring when plowed fields and vegetation such as oats, alfalfa and pasture dominate the scene, then MSS7 is by far the superior single-band product. MSS5 is not nearly as distinct and little crop classification can be accomplished. However, when the growing season progresses into July and August, a switchover takes place. MSS7 becomes a less distinct product to work with and MSS5 starts to show more distinct field patterns. This spectral response change should lend itself to multispectral and sequential pattern recognition procedures which would allow complete classification. These points are demonstrated in Figures 6 and 7. Figure 8, which is a color infrared print of a portion of the Doon flightline, is included for the convenience of persons reading this report. This area is noted on the ERTS-1 imagery in Figures 6 and 7. Before the next reporting date, the author intends to have miniadcol produced prints of each ERTS-1 coverage of the Doon area.

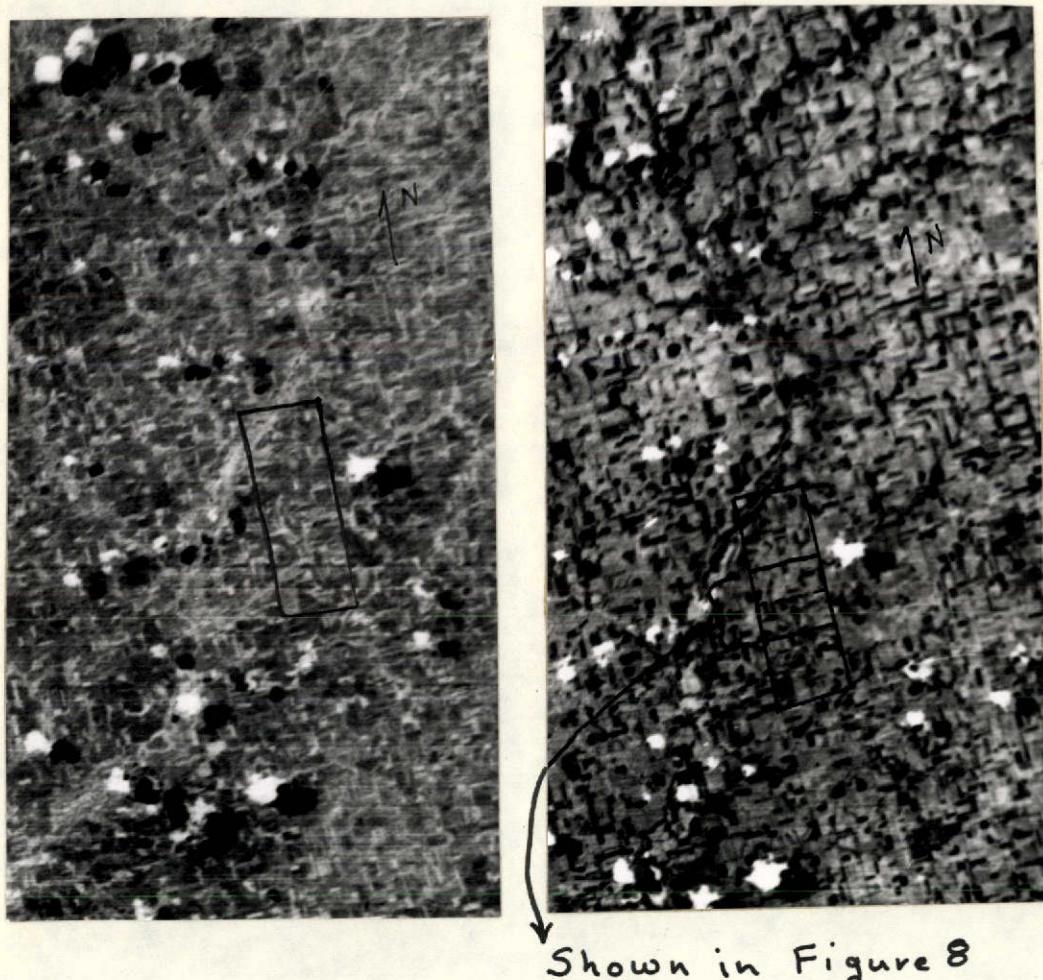


Figure 6. MSS5 (left) and MSS7 (right) black and white enlargements from 70 mm positive transparencies. The date was May 30, 1973 and the Doon flightline is noted.

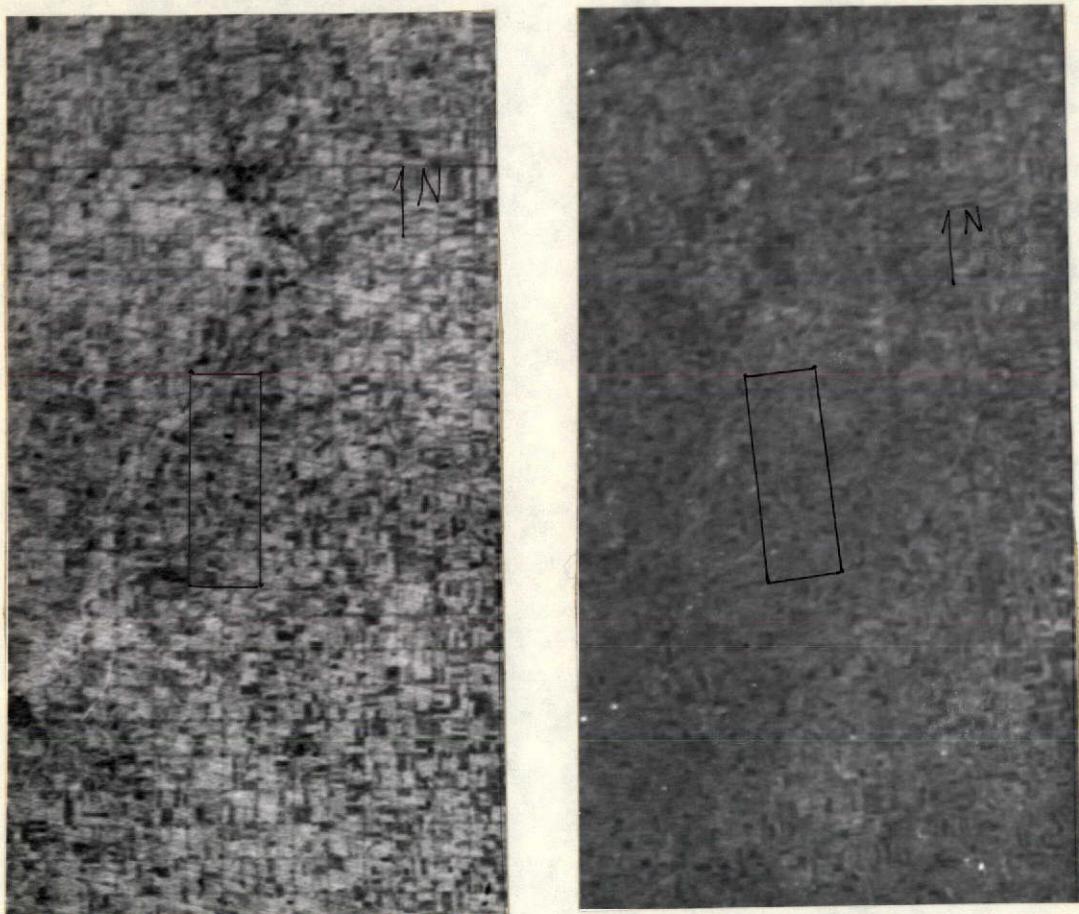


Figure 7. MSS5 (left) and MSS7 (right) black and white enlargements from 70 mm positive transparencies. The date was July 5, 1973 and the Doon flightline is noted.

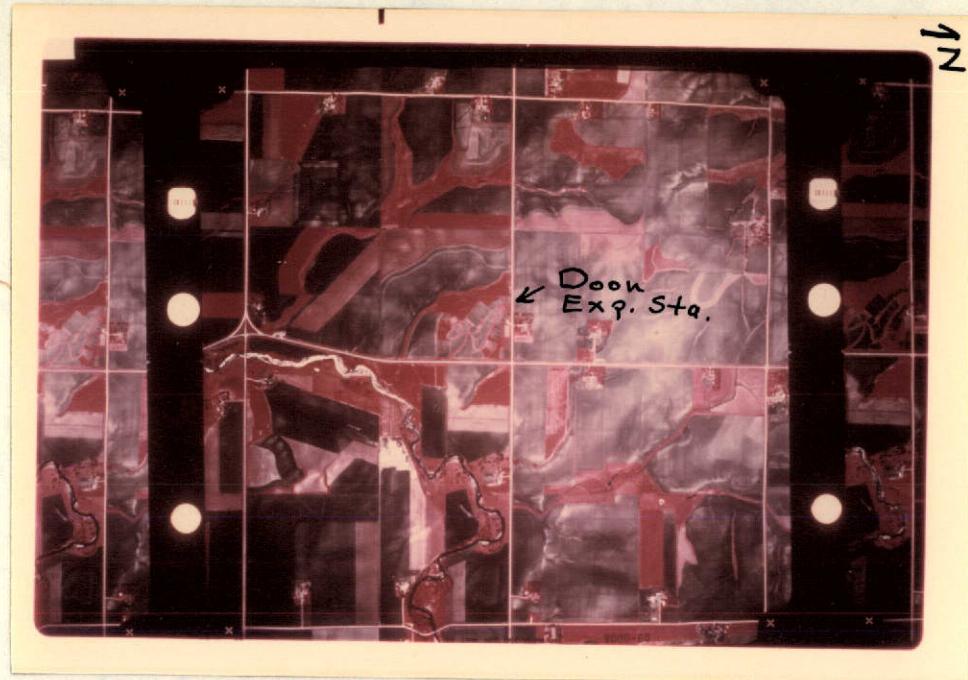


Figure 8. A color infrared print covering a portion of the Doon flightline. The flight date was May 15, 1973. Field types are designated on this print.

e) 1973 crop growing season - Ames flightline

Coverage of this flightline has been less numerous than the Doon flightline. The two times when ERTS-1 passed over have, however, provided this research group with probably our best ERTS-1 imagery to date. A miniadcol produced color infrared print is shown in Figure 9. In addition, a color infrared print from the May 15, 1973 NASA provided underflight in this area is presented in Figure 10 and its location is indicated in Figure 9.

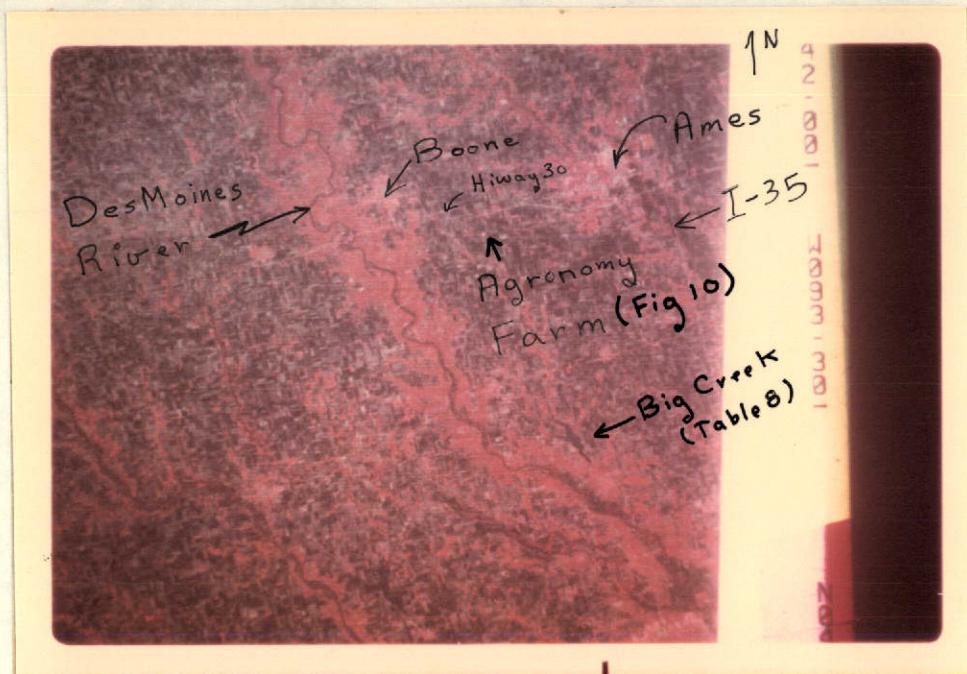


Figure 9. A miniadcol produced color infrared rendition of ERTS-1 imagery covering the Ames flightline on May 10, 1973. The Ames flightline is indicated.



Figure 10. A color infrared print covering a portion of the Ames flightline. The flight date was May 15, 1973. Field types are designated on this print.

Even though image clarity has been reduced in the production of these prints, the similarities between the two types of imagery are very striking. The utility of the ERTS-1 product depicted in Figure 9 for large scale synoptic land use is obvious. In early May, when this set of imagery was collected, oats, alfalfa, pasture and forested lands appear in various shades of red. The lighter toned fields in both prints are indicative of fields free of growing vegetation, but not plowed. The plowed fields appear dark on these prints. Area estimates have not been attempted at this date, but point sampling identification should be very good. ERTS-1 imagery covering this area in early July has just been received and analysis of this imagery is just beginning. A first look at the July 70 mm positive transparencies indicates that image clarity is quite good, and meaningful results can be expected. Separation of various field types will be attempted using both sets of ERTS-1 imagery in concert.

f) Spring 1973 ERTS-1 imagery covering Iowa

In addition to the crop classification and inventory portions of this investigation, this group is attempting to compile ERTS-1 imagery covering the entire state of Iowa during the months of May and June in 1973. A partial mosaic of the state has been constructed using MSS7 black and white enlargements. ERTS-1 coverage of the state not included to date for the partial mosaic has been requested. The intended use of the completed mosaic will be for large scale land use classifications and attempts will be made to correlate the ERTS-1 imagery with current soil association maps. Because black and white coverage is less desirable than color, the possibility of producing a color mosaic (similar to Figure 9) is being investigated by the group. We have not been fortunate enough to obtain cloud-free imagery over the entire state during one cycle; however, it appears that during the months of May and June only small changes in the relative spectral response of soils and vegetation occur.

Results and Discussion: Forestland Inventory by George W. Thomson, Professor of Forestry, Iowa State University

a) Classification of forest vs. nonforest and the determination of acreage of forest by use of a mechanical stage microscope.

An attempt was made to determine forest acreage directly from the 70 mm diapositive provided to collaborators by NASA. The test imagery was that from ERTS-1 of September 17, 1972, MSS5. The study area was the seven-township portion of Boone County, Iowa encompassing the Des Moines River drainage. (Note: this river system is shown in Figure 9).

Aligning the diapositive on the calibrated traversing stage of an AO microscope under the 4x lens the sample area was transected in an E-W direction through the center of each tier of six sections. For example, sections 1-6 would be sampled by one transect as would sections 7-12 etc. The forested portion of each transect was measured in millimeters as read from the calibrated vernier scale on the slide stage. These distances, when divided by the total length of each transect, resulted in an estimate of the percentage of land in forest cover.

To evaluate the microscope procedure for use in forest sampling, these percentages were compared by regression analysis with transects taken from 1:7,920 enlargements of conventional ACSC photographs taken in 1965. The information taken from the enlargements may be assumed to be equivalent to ground truth.

Utilizing the 42 transects from each of the two procedures the regression coefficients and appropriate error statistics were computed.

$$\begin{array}{llll} Y = .0219 + 1.1636 X & r = .7997^{**} & t_b = 1.1838^{\text{ns}} \\ Y = \text{forested land \% (microscope)} & s_b = .1382 & t_a = 1.5532^{\text{ns}} \\ X = \text{forested land \% (ACSC photos)} & s_{\bar{y} \cdot x} = .0141 & t_{\text{dep.}} = -3.5275^{**} \end{array}$$

The linear correlation coefficient, r , was significant at $p = .05$; the slope coefficient did not differ significantly from 1.00; the Y -intercept did not differ significantly from 0 ($p = .05$). From the foregoing it can be assumed that the forested percentage of six sections of land would not differ significantly between methods for determining it, i.e. microscope on small scale ERTS imagery vs. large scale convectional photography. However, the forested portion of the 252 sections analyzed by the microscope technique was 20.49% as opposed to 15.73% found from aerial photographs. This overall difference between means was significant ($p = .01$).

Because of the physical problems of enlargement of ERTS-1 imagery with the attendant loss of resolution and difficulty in carrying out area measurement by either mechanical planimeters or by point sampling it is believed that direct transecting with a low power microscope provides a practical solution to the problem of extensive forest sampling.

It is assumed that September, MSS5 imagery did not provide sufficient contrast in reflectance between forest and pasture or open woods and that the use of imagery from other spectral bands or calendar dates will be more successful. This assumption will be tested.

b) ERTS-1 imagery assists in evaluating the magnitude of loss of forest land

It has become an article of faith that Iowa had 6,680,926 acres of woodland when the state was surveyed for settlement in the mid-19th century and that more than 60 percent decrease in forest land has taken place. However, intensive research of the records for a test county (Bonne) indicates that the vagaries of observation, definition of the term "forest", and sampling procedures obscure both the amount of timber and its change. ERTS-1 imagery may provide a more precise record of the state's woodlands than has so far been obtained.

The following table provides a comparison between past and present inventories of the forests of Boone County, Iowa.

Table 7. Acres of natural timberland in Boone County, Iowa.

Township	G.L.O. Plat 1832-1859	Natural Timber 1874 Census	Andreas Atlas 1875	Iowa State Planning Board 1933	ASCS Photos 1965	ERTS-1 Enlargement 1972
<u>Acres</u>						
Grant	0	36	0	0	0	0
Pilot Md.	11605	705	9160	6451	5517	4254
Dodge	2037	2569	2406	4838	1046	1772
Harrison	528	486	794	1152	340	--*
Amaqua	0	264	0	230	0	0
Yell	11011	2261	9370	7603	4833	3395
Des Moines	5446	3299	4250	6912	1718	2796
Jackson	798	280	768	3226	516	--
Beaver	0	15	179	230	57	--
Marcy	2984	2125	2867	4147	1639	517
Worth	13314	3775	11766	7142	5875	6497
Colfax	0	429	0	0	0	0
Union	1349	919	947	922	506	--
Peoples	0	528	0	0	0	0
Douglas-Cass	12294	5762	9754	8179	4748	4718
Garden	92	97	205	461	115	--
TOTAL	61458	23550	52466	51493	26910	(23949) Partial
<u>Drainage</u>						
Des Moines R.	58691	21024	49573	45272	25376	23949
Beaver Creek	1349	1234	1126	1382	563	--
Squaw &						
Onion Cr.	1326	766	1562	4378	856	--
Big Creek	92	526	205	461	115	--

* -- indicates that no measurements were attempted

c) Area determination of a reservoir by use of a low power microscope, 70 mm imagery and the Double Meridian Distance (D.M.D.) procedure.

As the satellite view of a reservoir provides a sharply delineated boundary on the 70 mm ERTS diapositive, it seems logical that the traversing, calibrated stage of a microscope can be utilized to determine the conventional latitudes and departures called for in finding the area of a closed traverse by conventional surveying methodology.

The recently completed Big Creek Reservoir in Polk County, Iowa is now filling and is clearly visible on the MSS5 and/or 7 imagery of August 13, 1972, September 17, 1972, April 3, 1973 and May 9, 1973. This reservoir was used to study the feasibility of the D.M.D. technique.

Procedure:

1. Orientation to north is not critical to this technique but the imagery was aligned so that transect lines were essentially E-W.
2. Transect lines were set .15 mm apart (a distance of approximately 1,600 ground feet). X-Y coordinates for the lake boundary were read.
3. Starting one-half interval from the east edge of the dam the X-scale values were recorded adjacent to the Y-scale values for that transect. These paired values were kept in order in the same sequence that a surveyor would employ if on the ground.
4. Upon completing the traverse, the ΔX and $(Y)(\Delta X)$ computations were made and the area of the figure were computed in square millimeters. (Refer to any standard text on land survey). See example below.
5. The scale of the imagery must be carefully determined. In this test, two clearly locatable and well-mapped points approximately ten miles apart were used to determine the scale for each set of imagery.
6. The acres per square millimeter conversion was determined for the average scale and the reservoir acreage determined.

Table 8. Computation of acreage of Big Creek Reservoir, Iowa.

Imagery Date	Scale, ft/mm	Area of Image, mm ²	Average A./mm ²	Area of Reservoir, Acres D.M.D. Method
Aug. 13, 1972	10,877	.1625	2,785	453
Sept. 17, 1972	11,135	.1645	2,785	458
Apr. 3, 1973	11,021	.2230	2,785	621
May 9, 1973	11,022	.2525	2,785	703

Example of Double Meridian Distance calculation

Corner, i	Y Coordinate	X Coordinate	(ΔX)	$(Y)(\Delta X)$
0	113.90 mm	22.95 mm	+.10 mm	+11.39 mm ²
1	114.05	22.95	-.05	-5.70
2	114.20	23.00	-.05	-5.71
15	114.20	23.15	+.10	+11.42
16	114.05	23.05	+.20	+22.81
0				Sum = -.329

$$\text{Area, mm}^2 = .329 \div 2 = .1645 \text{ mm}^2$$

$$\text{Area, acres} = (.1645) (2,785) = 458 \text{ acres}$$

SIGNIFICANT RESULTS

1A. Crop Survey and Classification

Classification of major crop types at three locations in Iowa: 1972 crop growing season ---- R.E. Carlson, Assistant Professor of Agricultural Climatology, Iowa State University.

Ground truth was established for three areas in Iowa by on the ground inspection and by examination of underflight imagery in these areas. Attempts were made to classify the type and amount of vegetation in these areas using the August ERTS-1 imagery. Various techniques were employed using both multi-band and single-band photointerpretive methods. No digitized ERTS-1 data have been acquired to date. Expected signatures of predominant crop types were established from the available ground truth. Point sampling methods were used to identify field types. Then acreage amounts of crop types present in portions of these flightlines were estimated using miniadcol produced color slides, black and white single-band enlargements and photomicrographs. The ability to estimate acreages depended on the quality of the ERTS-1 imagery, the distinctness of the spectral separation of crop types in question, the ability of the PI to accurately place field boundaries, and the size and shape of fields under examination. Basically, these methods employed a project, trace, cut and weigh procedure. Fields were traced, cut and weighed according to previously established signatures using mainly MSS5 and MSS7. The weights of areas in question were converted to acreages by using an adjacent area calibration strip. These results varied depending on the crop type estimated, on the method used and on the quality of the ERTS-1 imagery. Acreage estimates, when compared to available ground truth, varied from one-two percent error to as much as 15 percent error in extreme cases where the spectral response between crop types was poor. Although these were probably significant errors, it must be realized that this analysis was based on only one time frame. In crop classification, many of the above problems can be minimized by sequentially interpreting ERTS-1 imagery during the entire crop growing season. This is being attempted using the 1973 ERTS-1 imagery covering Iowa at three test sites where ERTS-1 coverage has sequentially been excellent.

SIGNIFICANT RESULTS

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Ground truth has been established for three areas in Iowa by on the ground inspection and by examination of underflight imagery in these areas. Attempts are being made to classify the type and amount of vegetation in these areas using sequential ERTS-1 imagery and the experience gained from this type of investigation during the single ERTS-1 coverage of these areas during the 1972 crop growing season. The techniques used will include both single-band and multi-band interpretation at one time and, also, at sequential times. Additive color procedures will be employed when available. ERTS-1 has successfully viewed one flightline five times during the 1973 growing season. Digitized ERTS-1 data has not been acquired so standard photo-interpretative procedures will be employed. During the 1972 single ERTS-1 coverage of these test sites, it was very difficult to visually separate soybean fields from uncut alfalfa fields. These same problems held for visual separation of corn fields from other vegetated surfaces such as some pasture land, oats and oats stubble regrowth and sparcely wooded areas. Preliminary analysis of the spring 1973 ERTS-1 coverage indicates that these problems should be minimized. Problem fields confused with either corn or soybeans in the August coverage appear quite distinct in the spring coverage and can be accounted for at that time. Corn and soybean fields appear as soil in the spring and, as with last years data, these fields should become separatable in July or August depending upon the quality of the ERTS-1 imagery and the weather condition occurring. Field size and configuration may still pose problems, but utilization of multi-band and sequential coverage of the same area should enhance the results of this crop inventory investigation.

SIGNIFICANT RESULTS
1B. Timber Survey and Classification

ERTS-1 Imagery Assists in Evaluating the Magnitude of Loss of Forest Land ----
 George W. Thomson, Professor of Forestry, Iowa State University.

It has become an article of faith that Iowa had 6,680,926 acres of woodland when the state was surveyed for settlement in the mid-19th century and that more than 60 percent decrease in forest land has taken place. However, intensive research of the records for a test county (Boone) indicates that the vagaries of observation, definition of the term "forest", and sampling procedures obscure both the amount of timber and its change. ERTS-1 imagery may provide a more precise record of the state's woodlands than has so far been obtained.

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SIGNIFICANT RESULTS
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An attempt was made to determine forest acreage directly from the 70 mm diapositive provided to collaborators by NASA. The test imagery was that from ERTS-1 of September 17, 1972, MSS5. The study area was the seven-township portion of Boone County, Iowa encompassing the Des Moines River drainage.

Aligning the diapositive on the calibrated traversing stage of an A0 microscope under the 4x lens the sample area was transected in an E-W direction through the center of each tier of six sections 7-12 etc. The forested portion of each transect was measured in millimeters as read from the calibrated vernier scale on the slide stage. These distances, when divided by the total length of each transect, resulted in an estimate of the percentage of land in forest cover.

To evaluate the microscope procedure for use in forest sampling these percentages were compared by regression analysis with transects taken from 1:7,920 enlargements of conventional ASCS photographs taken in 1965. The information taken from the enlargements may be assumed to be equivalent to ground truth.

Utilizing the 42 transects from each of the two procedures the regression coefficients and appropriate error statistics were computed.

$$\begin{array}{ll}
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The linear correlation coefficient, r , was significant at $p = .05$; the slope coefficient did not differ significantly from 1.00; the Y-intercept did not differ significantly from 0 ($p = .05$). From the foregoing, it can be assumed that the forested percentage of six sections of land would not differ significantly between methods for determining it, i.e. microscope on small scale ERTS imagery vs. large scale conventional photography. However, the forested portion of the 252 sections analyzed by the microscope technique was 20.49% as opposed to 15.73% found from aerial photographs. This overall difference between means was significant ($p = .01$).

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SIGNIFICANT RESULTS
8C. Classification and Pattern Recognition

Area Determination of a Reservoir by Use of a Low Power Microscope, 70 mm Imagery and the Double Meridian Distance (D.M.D.) Procedure ---- George W. Thomson, Professor of Forestry, Iowa State University.

As the satellite view of a reservoir provides a sharply delineated boundary on the 70 mm ERTS diapositive, it seems logical that the traversing, calibrated stage of a microscope can be utilized to determine the conventional latitudes and departures called for in finding the area of a closed traverse by conventional surveying methodology.

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Procedure:

1. Orientation to north is not critical to this technique but the imagery was aligned so that transect lines were essentially E-W.
2. Transect lines were set .15 mm apart (a distance of approximately 1,600 ground feet). X-Y coordinates for the lake boundary were read.
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4. Upon completing the traverse, the ΔX and $(Y)(\Delta X)$ computations were made and the area of the figure were computed in square millimeters. (Refer to any standard text on land survey). See example below.
5. The scale of the imagery must be carefully determined. In this test two clearly locatable and well-mapped points approximately ten miles apart were used to determine the scale for each set of imagery.
6. The acres per square millimeter conversion was determined for the average scale and the reservoir acreage determined.

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Example of Double Meridian Distance calculation

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16	114.05	23.05	+.20	+22.81
				Sum = -.329

$$\text{Area, mm} = .329 \div 2 = .1645 \text{ mm}^2$$

$$\text{Area, acres} = (.1645)(2,785) = 458 \text{ acres}$$

26

ERTS IMAGE DESCRIPTOR FORM
(See Instructions on Back)

DATE August 20, 1973

NDPF USE ONLY

D _____

N _____

ID _____

PRINCIPAL INVESTIGATOR Dr. J.P. Mahlstedt

GSFC NASA Contract NAS5-21839, MMC #249

ORGANIZATION Iowa Agriculture Experiment Station
Iowa State University, Ames

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	cropland	forest	rivers	
1311-16444-M	X		X	clouds, lakes
1292-16391-M	X		X	clouds
1272-16281-M				clouds, haze
1310-16390-M	X			clouds, haze
1256-16392-M	X		X	clouds, haze
1329-16443-M	X		X	lakes, dam
1325-16228-M	X		X	clouds
1347-16441-M	X		X	lakes
1326-16274-M	X	X	X	clouds
1344-16273-M	X	X	X	
1346-16390-M	X	X	X	clouds
1346-16383-M	X		X	

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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